MAGNETIC FIELDS OF THE GALILEAN SATELLITES

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As of the writing of this abstract, Galileo has flown by each of the Galilean satellites at least once, making one pass through the wake region of each. The strongest interaction with the Jovian magnetosphere, as expected, was found at Io. Io's volcanism revealed its internal activity over a decade ago and made it a prime candidate for dynamo action in a liquid core. That same volcanism, however, also produces an atmosphere that interacts strongly with the Jovian magnetosphere distorting the field around the moon. The field in the Io wake due to this interaction with the Jovian magnetosphere helps mask that due to the intrinsic field of Io. Thus all we can calculate for Io at this time is an upper limit to the magnetic moment of 10^{13} Tm^3.

The passage of Galileo through the wakes of Europa and Callisto revealed a much more benign interaction than that at Io. The weaker external fields, combined with the weaker interaction with any atmospheres of these moons, allow a much more stringent upper limit be placed on the intrinsic magnetic fields of these moons. We calculate that the intrinsic field of Callisto can be no greater than 2×10^{11} Tm^3.

Galileo has now flown by Ganymede twice, once at low latitude through the wake region and once at high latitude, only 250 km above the surface of Ganymede. Both encounters revealed the same strong, dipolar magnetic field corresponding to a magnetic moment of 1.4×10^{13} Tm^3 and a magnetic field at the pole of over 10 times that of the background Jovian magnetosphere. Such a strong field far exceeds the field that could be produced by induction effects. The maximum field at the pole that could be produced by ferromagnetic or paramagnetic material is only three times the external field.

In order to produce such a field through natural remanent magnetization, the external field must have been much larger than the present day field at Ganymede, and this field must have been acquired over a significant depth of ferromagnetic material while the external field underwent no reversals. We consider this scenario rather unlikely and prefer the hypothesis that Ganymede's field is generated by an internal dynamo possibly amplifying a seed field provided by the Jovian background field. An iron, iron-sulfide core is consistent with the gravity data.